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HISTORY AND DESCRIPTION OF THE MISSISSIPPI BASIN MODEL.(U)
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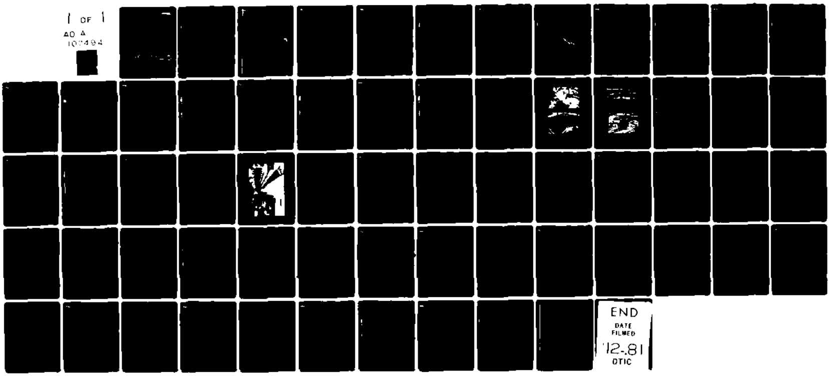

MISSISSIPPI BASIN MODEL REPORT 1-6

HISTORY AND DESCRIPTION OF THE MISSISSIPPI BASIN MODEL

by

J. E. Foster

August 1971

Sponsored by Office, Chief of Engineers, U. S. Army

Conducted by U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

MISSISSIPPI BASIN MODEL REPORTS

Issued Prior to and Including This Report

Report No.	Title	Date
1-1	Preliminary Report on Proposed Reservoir Operation Model, Mississippi River and Tributaries	October 1942
1-2	Report on Proposed Site	October 1942
1-3	Definite Project Report	April 1943
1-4	Description of the Mississippi Basin Model	July 1951
1-5	Automatic Instrumentation of the Mississippi Basin Model	November 1955
1-6	History and Description of the Mississippi Basin Model	August 1971
2-1	Report of First Meeting of Mississippi Basin Model Board	October 1945
2-2	Report of Second Meeting of Mississippi Basin Model Board	March 1947
2-3	Report of Third Meeting of Mississippi Basin Model Board	May 1948
2-4	Report of Fourth Meeting of Mississippi Basin Model Board	August 1948
2-5	Report of Fifth Meeting of Mississippi Basin Model Board	June 1949
2-6	Report of Sixth Meeting of Mississippi Basin Model Board	March 1950
2-7	Report of Seventh Meeting of Mississippi Basin Model Board	March 1951
2-8	Report of Eighth Meeting of Mississippi Basin Model Board	August 1952
2-9	Report of Ninth Meeting of Mississippi Basin Model Board	September 1953
2-10	Report of Tenth Meeting of Mississippi Basin Model Board	October 1954
2-11	Report of Eleventh Meeting of Mississippi Basin Model Board	October 1955
2-12	Report of Twelfth Meeting of Mississippi Basin Model Board	May 1956
2-13	Report of Thirteenth (Fiscal Year 1957) Meeting of Mississippi Basin Model Board	May 1957
2-14	Report of Fourteenth (Fiscal Year 1958) Meeting of Mississippi Basin Model Board	May 1958
2-15	Report of Fifteenth (Fiscal Year 1959) Meeting of Mississippi Basin Model Board	May 1959
2-16	Report of Sixteenth Meeting of Mississippi Basin Model Board, Fiscal Year 1960	June 1960
2-17	Special Report of the Mississippi Basin Model on Curtailment of Model Limits (Seventeenth Meeting of the Board)	September 1960
2-18	Report of Eighteenth Meeting of Mississippi Basin Model Board, Fiscal Year 1961	July 1961
2-19	Report of Nineteenth Meeting of Mississippi Basin Model Board	July 1962
2-20	Report of Twentieth Meeting of Mississippi Basin Model Board	August 1963
2-21	Report of Twenty-First Meeting of Mississippi Basin Model Board	April 1964
2-22	Report of Twenty-Second Meeting of Mississippi Basin Model Board	April 1965
2-23	Report of Twenty-Third Meeting of Mississippi Basin Model Board	May 1966
2-24	Report of Twenty-Fourth Meeting of Mississippi Basin Model Board	June 1967
2-25	Report of Twenty-Fifth Meeting of Mississippi Basin Model Board	June 1968
2-26	Report of Twenty-Sixth Meeting of Mississippi Basin Model Board	June 1969
2-27	Report of Twenty-Seventh Meeting of Mississippi Basin Model Board	June 1970
3-1	The Mississippi Basin Model	Rev April 1958
12-1	Verification of Sioux City-to-Hermann Reach, Missouri River and Tributaries, 1950 and 1947 Floods	April 1952
12-2	Verification of Sioux City-to-Mouth Reach, Missouri River and Tributaries, 1952 and 1951 Floods	June 1962
13-1	Verification of the Pickwick Dam-Kentucky Dam Reach, Tennessee River and Tributaries, 1950 and 1948 Floods	December 1960
14-1	Verification of Tulsa-to-Van Buren Reach, Arkansas River and Tributaries, Spring 1941 and 1943 Floods	July 1951
14-2	Verification of Van Buren-to-Pine Bluff Reach, Arkansas River and Tributaries, Spring 1941 and 1943 Floods	November 1952
15-1	Verification of Hannibal-to-St. Louis Reach, Mississippi River and Tributaries, 1947, 1944, and 1943 Floods	August 1951
15-2	Verification of Hannibal-to-Thebes Reach, Mississippi River and Tributaries, 1947, 1944, and 1943 Floods	May 1952
23-1	Effects of Reservoirs and Results of Steady-Flow Tests, Cumberland River	June 1965
23-2	Kentucky Reservoir Steady Flow Profiles and Effects of Pickwick Discharge Duration on Downstream Stages	July 1965
23-3	Effects of Cheatham and Barkley Reservoirs and Coordinated Operation of Barkley and Kentucky Reservoirs, Cumberland and Tennessee Rivers	May 1969
24-1	Flood-Routing and Reservoir-Operation Study, Tulsa-to-Van Buren Reach, Arkansas River and Tributaries	April 1961
31-1	Operation of the Birds Point-New Madrid Floodway	July 1957
31-2	Adequacy of Project Levee Grades in Hannibal-to-Thebes Reach, Mississippi River and Tributaries	April 1957
31-3	Proposed Alignments for Columbia Bottoms Levee, St. Louis Industrial Park	January 1960
31-4	Mississippi River Hypothetical Flood 52A	September 1962
32-1	Effects of Agricultural Levees on Design Flood Profiles for Kansas City Local Protection	May 1955
32-2	Tests for Re-evaluation of Missouri River Agricultural Levees in the Kansas City District	December 1959
32-3	Tests for Re-evaluation of Missouri River Agricultural Levees in the Omaha District	May 1960
34-1	Effects of Project Levees Along Point Remove Creek, Tributary of Arkansas River	June 1956
34-2	Adequacy of Project Levee Grades Without and with Reservoir Modification, Van Buren to Pine Bluff, Arkansas River	April 1957
42-1	Hypothetical Storms over the Iowa Tributaries	October 1956
43-1	The Ohio River Hypothetical Flood OR-1	February 1962
44-1	Determination of Discharge Hydrographs for Arkansas River and Tributaries, April 1927 Flood	June 1956
52-1	Tests of Channel Realignment near St. Joseph, Missouri	October 1954
81-1	Effects of Proposed Highway Fill Across Chouteau Island	January 1959
81-2	Effects of Proposed Chain of Rocks Dam, Mississippi River, Mile 190.1	September 1959
81-3	Effects of Roadway Construction on Mississippi River Flow, Lake County, Tennessee	December 1967
86-1	Effects of Roadway Embankment and Waterway Openings of Proposed Interstate Highway 155 on Mississippi River Floods	July 1966
92-1	Effects of Flood Heights of Levee, Railroad, and Highway Fills in the Flood Plain of the Missouri River	October 1955

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The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

LEVEL II

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MISSISSIPPI BASIN MODEL REPORT 1-6

(6) HISTORY AND DESCRIPTION OF THE MISSISSIPPI BASIN MODEL

by

(10) J. E. Foster

(14) WES-MBM-BASIN MODEL 1-6

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Sponsored by Office, Chief of Engineers, U. S. Army

Conducted by U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

ARMY-MRC VICKSBURG, MISS

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FOREWORD

Construction of the Mississippi Basin Model (MBM) was approved in letter of 29 July 1943, from the Office, Chief of Engineers, to President, Mississippi River Commission, subject, Reservoir Operation Model for the Mississippi River and Tributaries. Construction on the model site was begun in August 1943 and the model was completed in December 1966.

Although construction of the model was in progress until 1966, individual sections were put into operation as early as 1949. All scheduled tests were completed in 1971 and the model was put on a standby basis.

The construction of the model was under the general supervision of Mr. G. W. Vinzant, Chief, Construction Services Division, U. S. Army Engineer Waterways Experiment Station (WES), and the immediate supervision of each of the following engineers during a portion of the construction period: CPT H. G. Dewey, Jr., Mr. A. G. Davis, Mr. L. E. Crowder, Mr. W. C. Hunt, Mr. R. E. Hinton, and Mr. T. A. Leggett.

The operation of the model was under the general supervision of Mr. E. P. Fortson, Jr., Chief, Hydraulics Division, WES, and Mr. G. B. Fenwick, Assistant Chief, and Mr. J. J. Franco, Chief, Waterways Branch. Engineers in immediate charge of model operation during various periods were: Mr. H. G. Dewey, Jr., Mr. H. C. McGee, and Mr. J. E. Foster. This report was prepared by Mr. Foster, assisted by Mrs. Mildred B. Johnson.

Directors of the WES during the period of construction and operation of the MBM were: Mr. G. H. Matthes, COL C. T. Newton, LTC R. D. King, COL H. J. Skidmore, COL C. H. Dunn, COL A. P. Rollins, Jr., COL Edmund H. Lang, COL Alex G. Sutton, Jr., COL John R. Oswalt, Jr., COL Levi A. Brown, and COL Ernest D. Peixotto. Technical Directors were Messrs. J. B. Tiffany and F. R. Brown.

CONTENTS

CONTENTS

SUMMARY

The Mississippi Basin Model, the largest small-scale working model in the world, reproduces the entire drainage basin of the Mississippi River and its tributary system to a horizontal scale of 1:2000 and a vertical scale of 1:100. The model has the appearance of a gigantic relief map with the streams and floodplains molded in concrete in their correct geographic locations.

Construction of the model was begun by German prisoners of war in the fall of 1943, was continued by civilian personnel of the U. S. Army Engineer Waterways Experiment Station (WES) after the prisoners were transferred in 1946, and was completed in 1966.

Testing of local problems for various Corps of Engineers Division and District offices within the basin was begun in 1949. Tests were conducted as requested by Division and District offices until 1971 when all scheduled tests were completed. A comprehensive testing program was begun in 1959 and was completed in 1969. Tests to aid in the development of computer programs were conducted during the period 1969-1971. When all scheduled tests were completed, the model was placed on standby maintenance pending the need for additional tests and was operated for viewing by the general public and technical visitors.

The comprehensive tests have been very effective in checking the adequacy of operational procedures for flood-control reservoirs and floodways in the basin. The special tests have been invaluable in assisting the Divisions and Districts in determining the design grade of levees and floodwalls, in demonstrating to levee board members and other interested persons the effectiveness of flood-control structures constructed or proposed by the U. S. Army Engineers, etc. The most spectacular use of the model was in flood prediction on the Missouri River during the April 1952 flood when the model was instrumental in pinpointing critical points along levees. The model tests indicated some levees should be raised and others would be overtopped to such an extent that there would not be time enough to raise them. Missouri River Division personnel said the model was one of the vital factors in the success of the flood fight that prevented flood damages of an estimated $65,000,000 and possibly loss of lives.

The Mississippi Basin Model Board (the group charged with determining policies and programs for development and operation of the model) unanimously agreed that the model has been a very valuable tool in solving many flood-control problems and in providing the answers to many of the questions with regard to the coordinated operation of reservoirs within the basin.

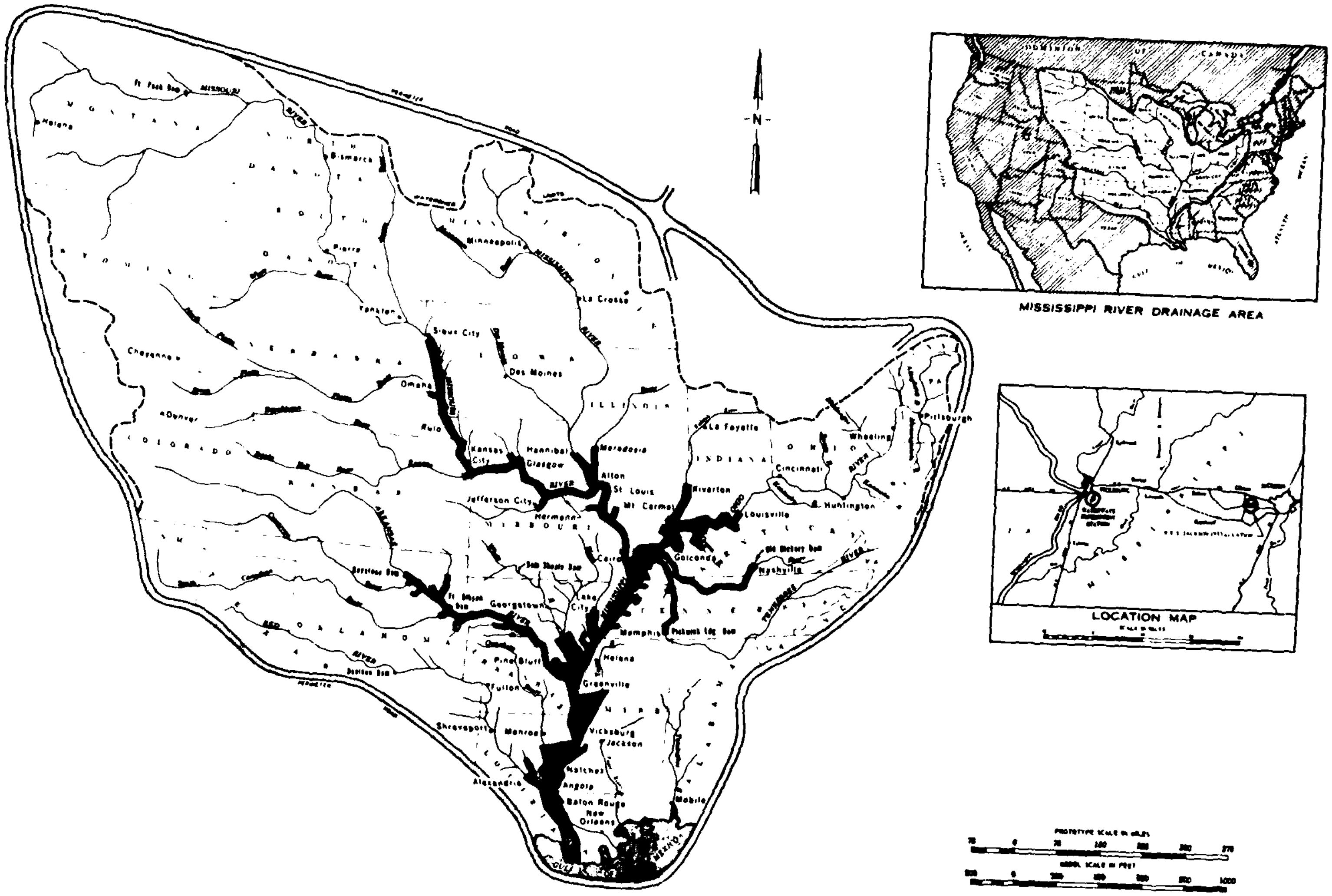


Fig. 1. Mississippi Basin Model

HISTORY AND DESCRIPTION OF THE MISSISSIPPI BASIN MODEL

PART I: INTRODUCTION

Description of Project

1. The Mississippi Basin Model (MBM), the largest small-scale working model in the world, reproduces the entire drainage basin of the Mississippi River and its tributary system (fig. 1). This basin, 1,250,000 square miles in area, extends from the Rocky Mountains to the Appalachian Mountains and from just above the Canadian border to the Gulf of Mexico. It contains all or parts of 31 states and two Canadian provinces, and occupies 41 percent of the continental United States. The model has the appearance of a gigantic relief map with the streams and floodplains molded in concrete in their correct geographic locations.

2. Construction of the MBM was begun by German prisoners of war in the fall of 1943 and was continued by civilian personnel of the U. S. Army Engineer Waterways Experiment Station (WES) after the prisoners were transferred in 1946. The model was completed in 1966. Testing of local problems for the various Corps of Engineers Division and District offices within the basin was begun on completed portions of the model in 1949. A comprehensive testing program was begun in 1959 and was completed in 1969. Testing for the various Division and District offices was completed in 1971. Tests to aid in the development of computer programs were conducted during the period 1969-1971.

Location of Project

3. The MBM is located at the Jackson Installation of the WES 9 miles west of Jackson, Miss., and 40 miles east of the main offices of the WES at Vicksburg, Miss.

PART II: PRELIMINARY PLANNING

Origin and Purpose of Model

4. The idea for a comprehensive model of the Mississippi River and its tributaries was conceived by MAJ Eugene Reybold while serving as District Engineer at Memphis, Tenn., during the record flood of 1937 on the Mississippi River. It was his idea that a comprehensive model could be used to develop plans for coordination of flood-control problems, chiefly reservoir operation, throughout the Mississippi River Basin. However, his idea did not begin to materialize until he became Chief of the U. S. Army Corps of Engineers during the early forties.

5. On 23 May 1942, Messrs. Gerard H. Matthes, Director, and Joseph B. Tiffany, Executive Officer, of the WES, while in Washington on WES business visited with Reybold, by then GEN Reybold, and Chief of Engineers. During their visit, GEN Reybold expressed the need for some means of controlling the overall operation of the basin-wide system of reservoirs. He told them of his conception of a comprehensive model that could be used as a tool for the study of the overall operation of the reservoirs in the Mississippi River Basin. GEN Reybold stated that such a model would have a great potential value for demonstrating flood-control measures to Government officials and laymen as well as to engineers. He said the model could be a means of convincing those responsible for flood-control legislation of the necessity for a central control of all reservoir operation during flood emergencies in the Mississippi River Basin. During Mr. Matthes' and Mr. Tiffany's visit, GEN Reybold orally directed them to conduct an investigation at the WES of the feasibility and practicability of constructing a hydraulic model of this type for studying problems arising from the operation of the 200 reservoirs, built and to be built, and other proposed flood-control works throughout the Mississippi Basin.

Plans for POW Labor

6. GEN Reybold was aware that personnel and materials were in short

supply during these critical years of World War II and that civilian labor would not be available to start construction of the model. Thus he conceived the idea of using prisoner-of-war (POW) labor for the preparation of the model site since much excavation and moving of dirt would be required to mold the terrain to the general topography of the Mississippi River Basin. GEN Reybold stated that German Field Marshal Rommel's forces which had just been captured in North Africa by the British Army could provide the labor force for the model. GEN Reybold immediately began negotiations through the Provost Marshal General for 3000 German prisoners of war to work on the model project and to obtain authority to construct an internment camp to be located adjacent to the model site.

Preliminary Study and Report

7. The investigation directed by GEN Reybold was made during the summer of 1942 under the supervision of BG M. C. Tyler, President, Mississippi River Commission (MRC). The WES was under the administrative supervision of the MRC at that time and until 10 August 1949, having been authorized and established under the President, MRC, in 1929.

8. A report of the investigation, Preliminary Report on Proposed Reservoir Operation Model--Mississippi River and Tributaries, was submitted to the Chief of Engineers on 19 October 1942. In his letter forwarding this report, GEN Tyler noted that the project as originally conceived had been altered considerably since GEN Reybold and Director Matthes had discussed the project. "It is now visualized," GEN Tyler said, "that the model is to be geographically undistorted and will be constructed in large part using prisoner-of-war labor."

9. In the preliminary report, paragraph 1, it was proposed to designate the model: "Reservoir Flood Control Model--Mississippi River and Tributaries."

Selection of Site

Investigation

10. A site board, composed of military and civilian employees, was

appointed by GEN Tyler to investigate suitable sites on or adjacent to the WES property for the proposed Reservoir Flood Control Model--Mississippi River and Tributaries. Pursuant to oral instructions of GEN Tyler, the Site Board convened for its first meeting at the WES on 3 October 1942. The members of the Site Board were COL Robert D. Whittaker, Chairman, MAJ Andrew B. Pickett, and LT Joseph T. Ware, Jr., of the Lower Mississippi Valley Division (LMVD), and Mr. Matthes, Mr. Tiffany, LT Joseph M. Caldwell, and Mr. Karl A. Dupes of the WES.

11. The board considered three possible sites for the location of the model: Site A (adjacent to the WES), Site B (near Warrington, Miss.), and Site C (near Clinton, Miss.). The advantages and disadvantages of each of these sites were presented in Report on Proposed Site, WES Report No. 1-2, dated 10 October 1942. Site C, an 800-acre site, 2 miles southeast of Clinton, 9 miles west of Jackson, and 35 miles east of the WES, was recommended by the Site Board. This site was preferred primarily because its physical features topographically fitted the model requirements more closely than the other sites investigated, and could be prepared with less excavation and fill than the other two sites; a railroad spur adjoined the property and a high voltage transmission line crossed the property; and there would be sufficient land on which to construct the Alien Enemy Internment Camp (POW), as only about one-third of the 800 acres would be needed for the construction of the model.

Approval

12. The site for the location of the model was approved by the Chief of Engineers in 1st Ind, dated 28 December 1942, to letter of 12 October 1942, subject, "Flood Control Model of Mississippi River System," from GEN Tyler.

POW Camp

Authority

13. Authority for the construction of the POW camp was contained in formal memorandum, dated 12 December 1942, subject, "Construction of Internment Camp," from Headquarters, Services of Supply, to the Chief of

Engineers. Concurrence by the Provost Marshal General was expressed in 1st Ind to the memorandum, dated 15 December 1942, addressed to the Chief of Engineers.

14. The Construction Division, Office, Chief of Engineers (OCE), in letter of 24 December 1942, subject, "Planning and Construction of 3,000-Man Prisoner-of-War Camp," directed the District Engineer, Mobile, Ala., to proceed with planning and construction of the camp at the model site. This same letter also provided for collaboration with the President, MRC, regarding the location and arrangement of the construction of the model, while at the same time maintaining proper control of the prisoners to be employed thereon during their absence from the compound proper. Under this plan of collaboration the District Engineer, Mobile, Ala., was authorized to proceed also with the construction of the necessary buildings to house employees of the WES needed to direct the work of the prisoners of war on the model site. All work was to be completed on or before 7 April 1943.

Construction and occupation

15. Plans for standard "theater-of-operations" type of construction of buildings for housing 3000 prisoners, a 151-bed hospital, and other buildings and facilities for the camp headquarters, escort companies, and a service command were approved by GEN Tyler in letter of 10 January 1943. Plans for a "theater-of-operations" type of buildings to house personnel of the MRC and WES connected with the design and construction of the model were also approved. Construction of these buildings and facilities was begun in January 1943. Operations began on 27 August 1943 with about 200 prisoners during the first week. This number increased to 1400 in October 1943 and reached the camp's peak of 1797 on 9 December 1943. This number varied with the need for labor on the model until March 1946 when all the prisoners were transferred from the project.

Definite Project Report

16. The Chief of Engineers, in the indorsement approving the model site referenced in paragraph 12, also tentatively approved the preliminary report on the proposed Reservoir Operation Model as a basis for further

study of this model and requested that a further report on the plans for constructing this model be submitted to OCE at the earliest practicable date. In general, he said, this report should include the information contained in a definite project report for flood-control projects.

17. The Definite Project Report, Reservoir Operation Model, Mississippi River and Tributaries, MBM Report No. 1-3, dated 8 April 1943, was submitted by the WES to the Chief of Engineers through the President, MRC. This report was approved on 11 June 1943, and the construction of the model proper was approved by letter of 29 July 1943. Actually, the construction of the model was approved in principle before the Definite Project Report was submitted; the site had been selected, and construction of the POW camp was in progress before the Definite Project Report was officially approved.

18. The following statement contained in the Definite Project Report set forth the anticipated ultimate development of the comprehensive model of the Mississippi River Basin:

> The proposed model would reproduce all streams in the Mississippi River watershed on which reservoirs for flood control are located or contemplated, together with all dams, levees, dikes, floodwalls, and other pertinent works built to a horizontal scale of 1 to 2000 and a vertical scale of 1 to 100.... It is planned to reproduce the lower Mississippi River initially only as far downstream as the mouth of the Old River for the reason that no flood inflow takes place below this point, and because, also, the Atchafalaya River Basin and its floodways and outlets are represented in an existing model at the U. S. Waterways Experiment Station. Provision would be made, however, for adding the remainder of the Mississippi River to its mouth and also the Atchafalaya River Basin at any time this might become desirable. Furthermore, the site for the model will permit the adding of the Tombigbee River, should it be desired at some future time to test out the effects of diverting flood waters of the Tennessee River to the Gulf of Mexico by way of the Tombigbee.

Change in Model Designation

19. The model was called Reservoir Flood Control Model in correspondence and reports until it was stated in the Definite Project Report that

it was considered undesirable to adopt any designation making use of the words "flood control model" as this would duplicate the name of an existing model at the WES. Furthermore, it was thought that the words "reservoir operation model" were truly descriptive of the uses to be made of the model and would place it in a class by itself, which it seemed to deserve. This name was used until 1 July 1946 when the name was officially changed to Mississippi Basin Model.

PART III: DESIGN AND CONSTRUCTION

Design Considerations

Selection of a grid system

20. Before actual construction work could begin it was necessary to establish a grid system on the ground for horizontal and vertical control. The range of latitude of the basin of the Mississippi River extends approximately from 29° to 49°N and the range of longitude from 47° to 114°W. No projection can give a true representation of such a large surface of the earth on a plane without introducing variation or distortion of scale, azimuth, or areas, particularly near the borders of the area under consideration. The Bonne projection, which was the one selected for laying out the model on the ground, maintains a more nearly uniform scale relation over the area by combining the best features of the polyconic and Lambert projections. The Bonne projection maintains close agreement in scale along the meridians and parallels, introducing only small errors in scale in the corners of the area to be mapped.

21. The field work of laying out the actual projection on the ground and maintaining it during the construction period naturally involved much work. To simplify this, a rectangular grid of 100-ft squares was superimposed on the Bonne projection. Each intersection of a degree of latitude and longitude on the Bonne grid thus had definite coordinates on the rectangular grid. In fact, any point on the Bonne projection could have its position expressed in coordinates on the rectangular grid.

Selection of linear scales

22. The scope of the project and the requisite vertical scale made use of an undistorted model impracticable. The horizontal scale selected for the model was the smallest deemed capable of reproducing flow conditions reliably, while the choice of vertical scale was governed by the precision required. The scales finally selected for the MBM had been used successfully at the WES on earlier model studies of flood-control problems. It was established that these scales, with the resulting distortion, were capable of reproducing reliable stage-discharge relations. Earlier models

had also demonstrated that as long as this relation was reproduced it was permissible to vary, within limits, the theoretical velocity, discharge, and time scales. The scales of the MBM were changed from the theoretical scales in order that the lower end of the model, where slopes are small and velocities are slow, could be adjusted to reproduce prototype occurrences.

23. Model-to-prototype scale ratios are as follows:

	Actual	Theoretical
Horizontal dimensions	1:2000	1:2000
Vertical dimensions	1:100	1:100
Time	1:267	1:200
Discharge	1:1,500,000	1:2,000,000
Velocity	1:7.5	1:10

Model limits

24. The MBM reproduces the entire drainage basin of the Mississippi River and its tributaries, which includes 41 percent of the continental United States and part of Canada from the Rocky Mountains to the Appalachian Mountains and from just above the Canadian border to the Gulf of Mexico. The entire drainage basin, covering 210 acres in the model, was graded to approximate elevations and was sodded to prevent erosion. The river channels and overbank flood areas were molded in concrete (this is the area used for testing). The initial plans for the model included the construction in concrete of all major streams in the basin to the headwaters. However, during the construction period, it became evident to the MBM Board (a group established in August 1945 charged with determining policies and programs for development and operation of the model) that certain areas of the basin, particularly the upper limits of some tributaries, that had been initially scheduled for construction in concrete were no longer needed in the model. Consequently, the completed concrete portion of the model is considerably less than that initially planned. The concrete portion of the model consists of the Mississippi River and its tributaries from Hannibal, Mo., to Baton Rouge, La., and the Atchafalaya River to the Gulf of Mexico, including the Missouri River to Sioux City, Iowa, the Ohio River to Louisville, Ky., the Cumberland River to above Nashville, Tenn., the Tennessee River to Pickwick Dam, the Arkansas River to above

Tulsa, Okla., and the Ouachita River to Monroe, La. The model limits are shown in fig. 1.

Physical data

25. The bulk of physical data required for the design, construction, verification, and operation of the MBM was furnished by the Division and District offices. Close liaison was maintained between the Divisions and Districts and the WES. Physical data assembled for use included:

- a. Surveys (hydrographic, topographic, and aerial photographic).
- b. Valley cross sections.
- c. Levee grades and alignment.
- d. Information relative to railroads, highways, bridges, etc.
- e. Location and extent of levee crevasses and washouts.
- f. Streamflow data (discharge measurements, stage measurements, rating curves, water-surface profiles).
- g. Aerial photographs and flood pictures.

Preparation of Model Site

Topography

26. Since the model site of 200 acres would develop into a giant relief map of the drainage basin of the Mississippi River requiring a maximum difference in elevation of 50 ft, selection of a site that would require a minimum of grading presented a difficult problem. The site finally selected was located in gently rolling terrain. It had as close a resemblance to the natural features of the Mississippi Basin as could be found anywhere near the WES. Nevertheless, approximately 1,000,000 cu yd of excavation was necessary to produce the required topography. The grading of the site was unusual in that topography consisting of ridges and valleys was formed rather than the usual grading operation in which a more or less level surface is desired.

POW labor

27. Actual work on the model site was begun with German POW labor in August 1943. Most of the prisoners interned at the POW camp were from Rommel's famed Afrika Korps. By the time the prisoners were repatriated in March 1946, most of the rough grading of the site for the model proper was

completed--the prisoners had moved a total of 1,000,000 cu yd of earth, dug a drainage ditch around the upper limits of the model, and installed most of the storm-sewer system underlying the site.

28. When the prisoners were first assigned to the project, they showed much enthusiasm for the work which consisted mostly of clearing and grubbing and road construction. As a majority of the work changed to excavation with wheelbarrow and shovel, a general slowdown was noticed and a real indifference developed toward the work. In organizing the details to move dirt with wheelbarrows, it was found necessary to put the prisoners on a task system wherein they were required to move a certain amount of dirt during a given period of the day. The prisoners were used not only as common laborers, but also as surveymen, draftsmen, computers, engineering aides, inspectors, mechanics, cooks, and clerks. In general, their work was satisfactory except for the common labor group for whom the task system was found to be necessary before much work could be obtained. Fortunately, these ancient methods of moving dirt did not last many months, and heavy earth-moving equipment was used to complete the rough grading.

Grading and draining

29. In preparing the original grading plans for excavation, the cuts and fills were balanced for a haul not to exceed 500 ft in as many areas as possible. Limiting most of the haul to 500 ft was necessary in order to use POW labor for moving the dirt with wheelbarrows and shovels. This reduced to an absolute minimum the amount of heavy equipment required. In grading the site, great care was taken in compacting the fill which amounted to as much as 500,000 cu yd in the upper and lower Ohio River Basin alone. Obviously any settlement of the fill would have been disastrous to the model. The fill was made in accordance with standard construction procedures--by placing the earth in 8-in. lifts, obtaining the proper moisture content, and then rolling with sheepsfoot rollers to obtain the desired density. Placing the fill in layers also simplified the shaping of the topography. Contour maps were prepared to show the extent of each lift, or of several lifts, so that the proper shape of a ridge or valley could be obtained.

30. Plans for drainage of the model site included the rerouting of

a creek that flowed through the center of the area selected for the model and the installation of an extensive storm-sewer system to control runoff from rainfall on the model area. A drainage ditch was dug around the eastern and southern limits of the model to divert the flow of the creek around the model area. A storm-sewer system consisting of approximately 85,000 linear ft of pipe ranging in size from 6 to 60 in. was installed with inlets scattered throughout the entire 200-acre model site. The site preparation was completed by the fall of 1946.

Construction of Model

31. Construction of the concrete portion of the model was begun in 1946 and continued at a varying pace due to a lack of funds until its completion in 1966. The concrete portion of the model covers so large an area that it had to be constructed in sections with expansion joints between the sections to absorb the expansion and contraction of the concrete. Individual blocks were outlined on contour maps with a view toward keeping the blocks about 150 sq ft in size and rectangular in shape with the ends perpendicular to the channel alignment. In the beginning, the model was constructed in place on a carefully prepared subgrade by the template method of construction (the method generally used in model construction). However, because an expanding clay beneath the model caused excessive heaving of the model, a new method of construction (the contour method) was developed in 1953. Using this method, the model was molded on an assembly line, transported to the model site, and placed on concrete piles. This method was very effective in stabilizing the horizontal plane of the model. These two methods of model construction are described below.

Template method

32. The template method utilized sheet-metal templates cut to the cross sections obtained from topographic maps and set about 2 ft apart to the correct elevation on the model site in positions located by the rectangular grid system. Concrete was placed between the templates on the carefully prepared subgrade and molded to correct elevations at the templates. The topography was manually sketched between the templates under

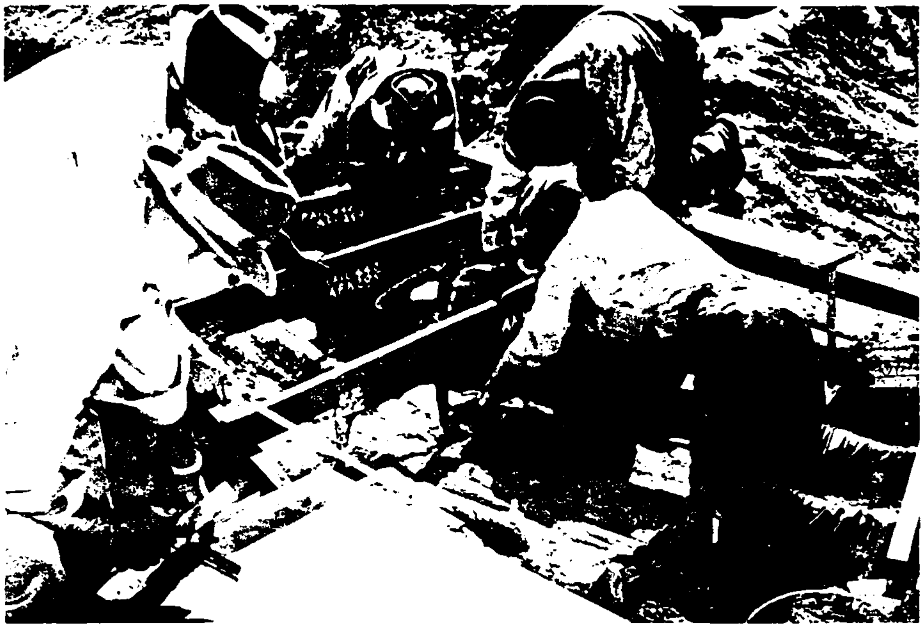
close control. Hydrographic and topographic maps, aerial photographs, and valley cross sections were used in developing the templates and sketching the model. Model channels were molded 0.1 ft low to permit future installation of roughness without infringing on the model channel area. Fig. 2a shows the model being constructed by this method.

Contour method

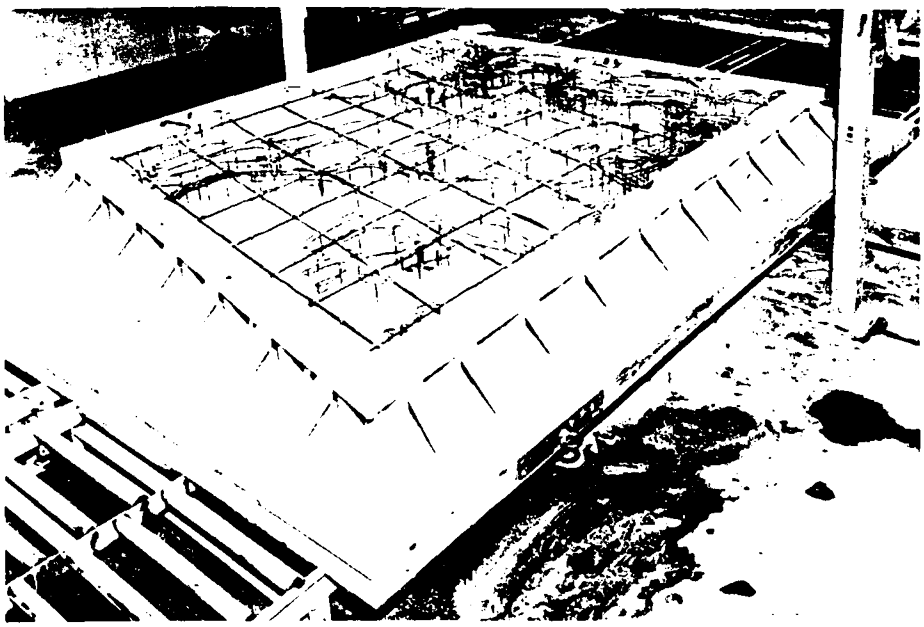
33. The contour method of model construction was developed by WES personnel in 1953 and was used for constructing the remainder of the model. Contour maps of the sections to be molded were enlarged to model scale and used as construction plans.

34. Box forms for each block were made of plywood with the sides of the box cut to the configuration of the boundaries of the block, and the model-scale contour maps were put in the bottom of the box. Strips of 22 gage metal 1/4 in. wide were bent to conform to the contours. Metal rods, 1/8 in. in diameter and cut to the height of each contour, were installed in holes drilled in the bottom of the box along the contours. The metal contours were inserted in slots in the top of these metal rods making a relief map of this section of the model. Screw jacks, to be used to support the block on piles at the model site, were placed in the box. Concrete was placed in the box and molded to the contours and brushed to a sand finish. Channel roughness elements were installed and curing compound was sprayed on the finished block. Fig. 2b shows a block being constructed by the contour method.

35. The blocks were allowed to cure for seven days before the side forms were removed, and then the blocks were carried by truck to the model site. The blocks were lifted from the truck and placed on 8-in. bell-bottom concrete piles that had been poured in place to a depth of 10 ft, which is generally below the expanding clay and where the moisture content is more or less stable. Metal bearing plates had been placed on the piles to receive the screw jacks. When the blocks were set to the correct grade, a void of about 1 ft was left between the ground and the blocks to prevent the upper layer of soil from pushing the block upward when it expanded (Fig. [illegible]a).

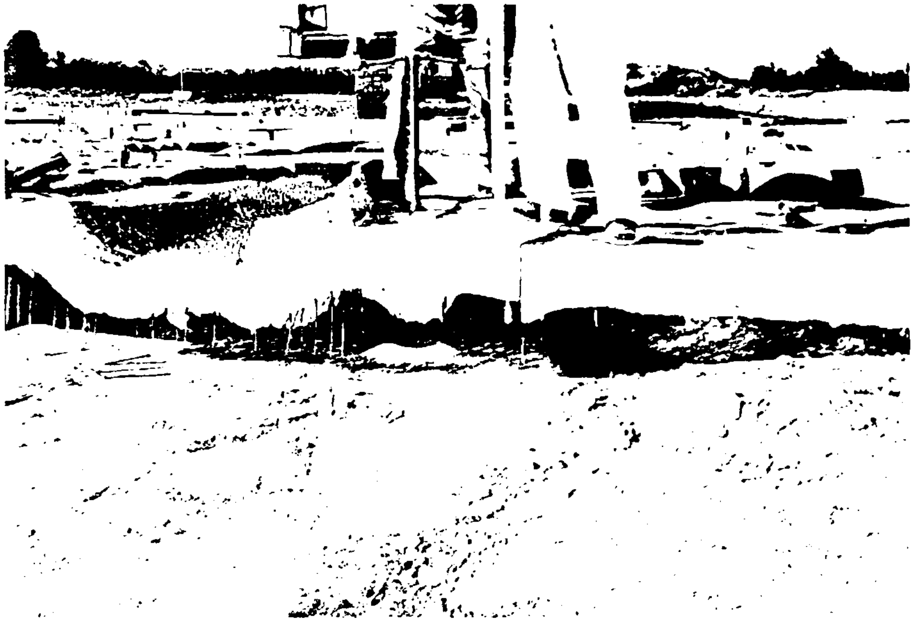


a. Sections being molded in place to templates set about 1.5 to 2.0 ft apart



b. Sections molded to metal contour on assembly line, then transported to model site

Fig. 2. Template and contour methods of model construction



a. Model slabs being positioned on piles

b. Completed model. Note levees, instrumentation, and roughness elements

Fig. 3. Model under construction and after completion

Installation of joint material

36. Many types of joint material were used during the construction of the model, but none have been effective in preventing leakage for a long period of time. The last method used and the most effective one consisted of forcing a thick rubber tube in the joint about 1 in. below the surface, filling this space with gun-grade caulking compound, and covering the joint and about 1 in. on each side of the joint with a thin strip of sprayed or brushed on cocoon (an elastic substance with fibers for strength). If cracks occur in the joints they can be patched by brushing a layer of fresh cocoon over the crack.

Installation of fills

37. Levee, highway, and railroad fills were installed on the model as they existed in nature. Federal levees and many private levees were installed to alignment and grade furnished by the various Districts. Federal and State highways and many local roads were installed to location and height furnished by the various State highway departments. Most railroad fills were installed according to plans furnished by various railroad companies. The remainder of the fills were installed as shown on floodplain and quadrangle maps.

Installation of roughness

38. Channel roughness elements consisting of brushed and scored concrete, concrete ridges, and concrete and brass parallelepipeds were installed to size and spacing determined from computations and pilot model studies. Prior to construction of the MBM, a pilot model was built and tested to aid in the solution of problems concerning the design and operation of the MBM. Tests were conducted on the pilot model to determine the type, size, and spacing of roughness elements necessary on the MBM to simulate prototype roughness of each reach. The most satisfactory channel roughness elements tested were 3/8- by 3/8-in. brass parallelepipeds of various lengths installed on 2-in. staggered spacing.

39. Folded screen wire cut to the scale of the average height of trees in the area was placed on the model where aerial photographs showed trees in the prototype. Expanded metal was fastened to the model on cleared areas where the brushed concrete did not provide adequate

resistance to flow. In some cases two and three layers of expanded metal were required. Fig. 3b shows the various types of roughness used on the model.

40. The model was constructed in sections to permit testing of short reaches as well as of the entire basin. These sections were built with removable blocks that make a continuous model when installed, but when removed they divert the flow from the model to a 90-deg V-notch weir, where the flow is measured, and to a pipe system that returns the water to a sump for storage and reuse.

PART IV: INSTRUMENTATION AND APPURTENANCES

Development and Procurement of Instruments

Automatic instruments a requisite

41. From the earliest stages of the development of the model, automatic instrumentation was considered desirable and necessary. In the Mississippi Basin the streams vary from alluvial streams with broad valleys and slow flood-moving characteristics of the plains and delta to the steep mountain streams subject to flash floods in narrow valleys. Flood waves in the streams of the plains and delta, which sometimes extend over a period of months, could be reproduced accurately in the model with manually operated instruments; but it was considered extremely difficult, if not impossible, to introduce accurately flash floods on mountain streams and chart their movements with manual instruments. For this reason automatic instrumentation appeared to be a requisite for conducting successful tests of flood waves on these streams.

42. The enormous amount of manpower required for manual operation of the model as originally projected was another factor that made automatic instrumentation desirable. A staff of about 600 would have been necessary for total manual operation. Training and maintaining a force of this size would have been a difficult and most expensive operation; hence, manual operation was considered undesirable from the standpoint of labor and cost.

Instrument problems studied

43. Approximately four years, 1943 to 1947, were devoted to the study of the problems of automatic instrumentation and to the testing of commercial and pilot instruments embodying various design principles. Instrument manufacturers throughout the United States (about 125) were consulted. A thorough investigation of the commercial instrument market disclosed that available instruments did not have the accuracy of measurement or the range required for use on the model. With 1/10 ft in prototype stage represented by 1/1000 ft in the model, 1 hr by 13-1/2 sec, and discharge of 1000 cfs by 7/10,000 cfs, it can readily be seen that instruments must possess great precision capabilities to measure accurately such

minute quantities. In general, the specification for the model instruments presented extraordinary problems for the instrument companies, and it finally became evident that the instruments would have to be specially designed to accomplish the required results.

44. For the sake of economy, instruments that could be interchanged were considered necessary. Complete interchangeability was not accomplished in all of the different types of instruments, but it was accomplished to a beneficial degree. Near the end of the fourth year of research enough knowledge and information had been acquired to write the specifications for the automatic instruments. The manufacturing companies were invited to bid on the instruments and to submit designs for instruments other than those described in the specifications that could accomplish the desired results. Consequently, some of the instruments acquired and now in use were not described in the specifications.

Instruments purchased

45. On 20 July 1948, contracts were awarded to Infilco, Inc., Chicago, Ill. (now of Tucson, Ariz.), for 76 inflow instruments and to Leupold and Stevens Instruments, Portland, Oreg., for 160 stage instruments.

Description of Instruments

Inflow instruments

46. The inflow instrument consists of a controller at the inflow point on the model and a programmer in a control house. The inflow controller is a multiple orifice device for controlling quantities of flow. There are 13 (in some instruments 14) fixed-opening orifices in each controller mounted on a plate between lower and upper cylindrical tanks. A rubber stopper closes each orifice until an electrical signal received from the programmer activates a pneumatic or magnetic lifting device that lifts the stopper and allows flow to pass through the orifice. A regulating system maintains a constant differential pressure across the orifices to assure accuracy of measurement.

47. The inflow programmer, a multiple electrical switch device, sends the electrical signals to the controller to operate the orifices in the proper sequence to provide the desired flow into the model. The

programmer can be operated manually from a panel of switches, each of which operates a particular orifice, or automatically from a perforated tape that passes over a tracker bar which reads the perforations and activates leaf switches that send electrical signals to operate the desired orifices. The automatic feature of the programmer is based on the vacuum principle originally used in player pianos some 40 years ago and in recent years to operate automatic typewriters. The programmer tapes are perforated by a machine resembling a typewriter.

Stage instruments

48. The stage instrument is composed of a transmitter and a recorder with a telemetering circuit consisting of two selsyn motors--one in the transmitter and the other in the recorder--connected by an electrical cable. The stage transmitter, located over the model channel, measures the water-surface elevation by means of an electronic sensing probe and transmits this elevation to a recorder located in a control house. A pen on the recorder continually records the water-surface elevation on a chart that is turned at a given rate to give water-surface elevation versus time.

Outflow instruments

49. Discharges at various points on the model are obtained by diverting the flow of water at that point through a pipe to an outflow pit and over a 90-deg V-notch weir. The head over the weir is measured with a stage instrument and converted to discharge by means of a rating table developed for the weir. The stage just upstream from the outflow point is controlled by a metal tab in the channel or a movable weir in the outflow pit. This is done to provide the correct model storage so that the discharge measurement would be comparable to prototype discharges.

The timing unit

50. The timing unit consists of a master timer and a calendar that indicates the month, day, and hour in model time. All automatic instruments on the model are controlled by the master timer, which is a synchronous motor geared to cams that actuate relays to synchronize operation. The timer gives electrical impulses at 13.5-sec intervals (one prototype hour) which advance the perforated rolls of the flow programmers and operate a calendar in each control house. The calendar consists of a series

of relay circuits that operate lamps on the annunciator panel indicating the month, day, and hour so that model time can be visually observed while floods are being tested.

51. The operation of all instruments is governed from the control houses. In preparation for a test, the timer, the calendar, the program rolls in the inflow programmers, and the recorder charts on the stage recorders are set for the month, day, and hour of starting time; then by means of a single switch all instruments in the control house and on the model are started simultaneously.

Instrumentation report

52. A more detailed description of the instruments and how they function is given in MBM Report 1-5, Automatic Instrumentation of the Mississippi Basin Model, written by Mr. H. C. McGee, Chief of the Mississippi Basin Model Section for 15 years. Fig. 4 shows a typical layout of the instruments on the model and in a control house.

Operational Data Systems

Control houses

53. Centrally located buildings on the major streams for housing the flow programmers, stage recorders, and automatic calendars provide control centers for the automatic instrumentation and are known as the control houses (fig. 5). The humidity and temperature within the houses are controlled to minimize changes in dimensions of the stage-recorder charts. There are six control houses on the model: three on the Mississippi River at St. Louis, Mo., Helena, Ark., and Baton Rouge, La.; one on the Missouri River at Kansas City, Mo.; one on the Arkansas River at Fort Smith, Ark.; and one on the Ohio River at Cincinnati, Ohio.

Data-transmission system

54. An underground data-transmission system permits remote recording of stage data and remote control of inflow instruments from the control houses. Eight-conductor cables connect the stage transmitters on the model with the recorders in the control houses, and 20-conductor cables transmit

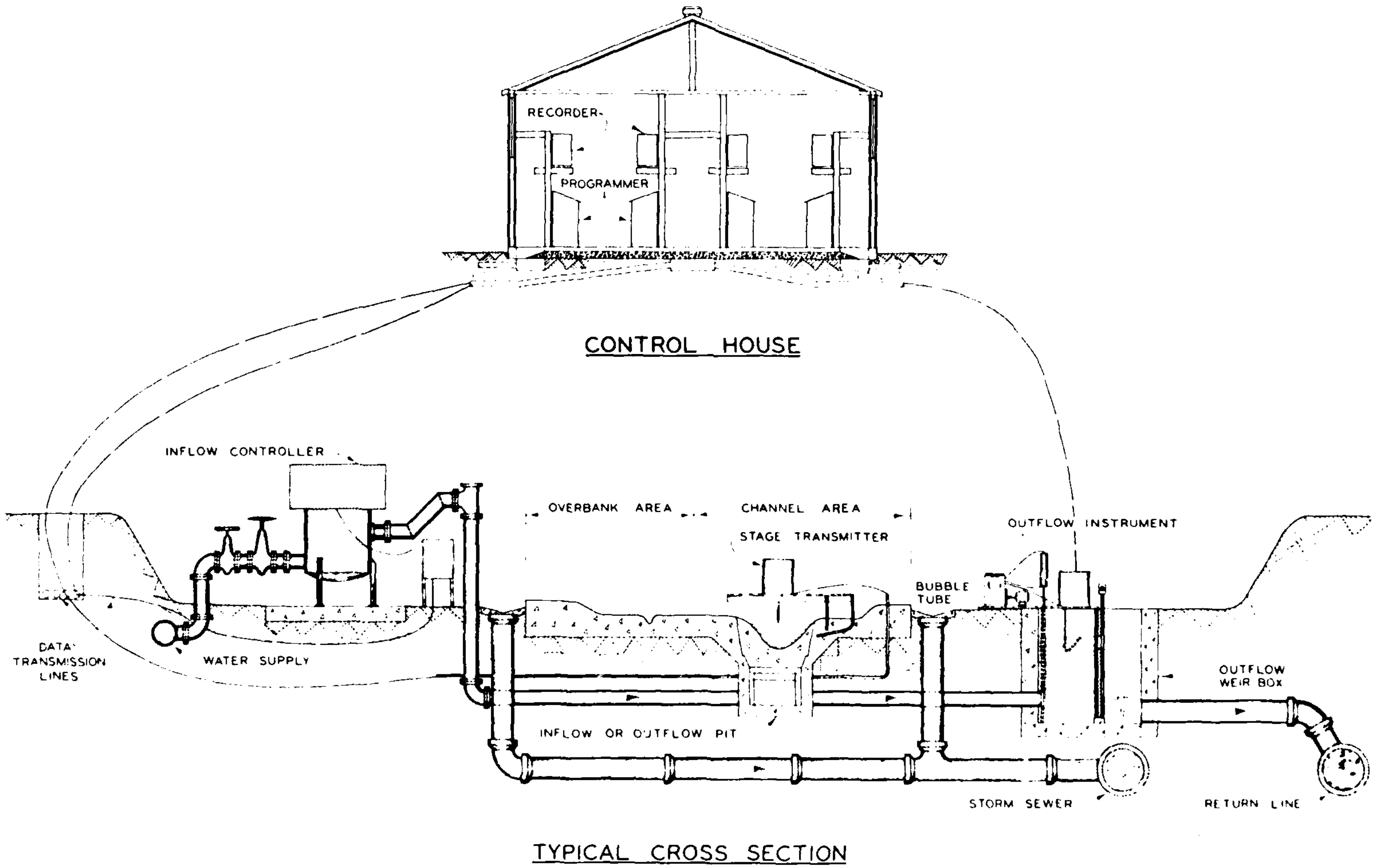


Fig. 4. Instrumentation for Mississippi Basin Model

flow data from the programmers in the control houses to the inflow controllers installed on the model.

Communication system

55. A two-way public address system is installed at each control house for communication between operators in the control house and those on the model. Outlets are provided at approximately 200-ft intervals on the model for the outdoor combination speaker-microphones; the two-conductor cable for the system is underground. Microphones in the control house are portable and separate from the speaker.

Compressed air system

56. A central compressor station was built to supply compressed air to operate the inflow controllers. A filtering and drying system was installed in the compressor station to remove certain impurities and moisture from the air. Air lines were installed from the station to each inflow controller.

Master timer signal line

57. A four-conductor cable transmits signals from the master timer to the control houses. The line does not originate at any particular point, but makes a continuous circuit between all control houses.

Utility Distribution Systems

Water supply system

58. Water is supplied to the model from a recirculating system, consisting of a large sump, 80 ft by 50 ft by 9 ft; two 2500-gpm, 150-ft head, vertical, turbine type pumps; a 500,000-gal elevated tank mounted on a tower approximately 98 ft above the model; supply lines to the inflow instruments on the constructed model, and return lines to the sump from the outflow points, where the water is diverted from the model. About 30,500 linear ft of supply and return lines of 4- to 30-in. pipe have been laid. The operation of the model as a unit requires a discharge of 2.0 cfs or about 1000 gpm, the peak flow required to reproduce the project flood in the lower Mississippi River. When several parts of the model are operated simultaneously, but independently, the volume of water required is much

greater. Provision was made for expanding the water supply system to include two additional 2500-gpm pumps if needed.

Electric power lines

59. Overhead power lines extend from the main supply lines to the control houses, whereas lines from the control houses to the instruments are underground. Special provision was made for floodlighting to permit operation of the model at night.

PART V: OPERATION

60. Although construction of the model was in progress until 1966, individual sections were put into operation as early as 1949. As a section of the model was completed, the roughness added, and the instruments installed, it was verified (i.e., made to reproduce prototype occurrences) and operated for local testing. By 1959 the model had been completed and verified downstream to Memphis, Tenn., and basin-wide testing was begun above Memphis. By the time the model was completed and verified to Baton Rouge, La., the basin-wide testing above Memphis was completed and these tests were conducted in the Memphis-to-Baton Rouge reach.

Verification

61. A recent flood of considerable magnitude, preferably the maximum flood of record, was selected for each reach of the model to use for verification. The model equivalents of the flows for this flood, from the low stages to the crest, were introduced at the model inflow points and the channel and overbank roughnesses were increased or decreased to make the model stages reproduce those of the prototype. With the model adjusted to reproduce past occurrences, it is expected to produce occurrences that may be experienced in the future.

Local Testing

62. Various types of tests have been conducted on the model to aid in the solution of local problems. Tests have been made to assist the Divisions and Districts in determining the design grade of levees; the effects on stages and discharges of constructing certain levees; the effects of crevassing certain backwater levees at different times during flood crests; the crest stages and discharges to be expected from certain hypothetical floods; the effects of highway, railroad, and levee fills on flood stages; the effects of various types of reservoir operation; etc.

(Table 1 lists the local tests conducted on the model and the title and identification number of the report published for each test.)

63. The most spectacular use of the model was during the April 1952 flood on the Missouri River when the model was used to predict flood stages. This flood was expected to have a crest discharge of almost twice the maximum flood of record at Sioux City, Iowa. The Missouri River Division (MRD) requested the WES to operate the MBM 24 hr a day during the critical period of the flood to assist them in predicting crest stages and discharges. The MBM was operated 16 days on a 24-hr-per-day basis and there were over a hundred telephone calls between the WES and MRD in which prototype conditions were given to the model personnel and model data were furnished MRD personnel. The first model tests indicated that the levees at Omaha and Council Bluffs were not high enough to contain the crest of this flood. After this prediction, the MRD evacuated the areas and built up the levees. When the flood crested at Omaha, over five days after the model warning, the original grades of these levees were exceeded, but with the additional height, they contained the flood and prevented Omaha and Council Bluffs from being flooded. The model tests also indicated other levees that should be raised and others that would be overtopped to such an extent that time would not permit raising them sufficiently to prevent them from being overtopped. From this information MRD personnel were able to concentrate their efforts on building up levees where there was a chance to prevent overtopping and evacuating people and their property from other areas. MRD personnel said the model was one of the vital factors in the success of the flood fight which prevented flood damages of an estimated $65,000,000 and possibly loss of lives.

Basin-Wide Testing

64. The comprehensive testing program was begun in Fiscal Year (FY) 1959 in the Hannibal, Mo.,-to-Memphis, Tenn., reach of the model which includes the Missouri River upstream to Sioux City, Iowa, and the Ohio River upstream to Louisville, Ky. The portion of the model downstream of Memphis was not completed and in order to speed up the testing program, it

was decided to conduct these tests in two parts: above Memphis and below Memphis. The tests above Memphis and the verification of the remainder of the model were completed in FY 1966. Comprehensive tests were begun in FY 1967 in the Memphis, Tenn.,-to-Baton Rouge, La., reach including the Arkansas River to Little Rock and the Atchafalaya River to the Gulf of Mexico. These tests were completed in FY 1969. These tests and the resulting data are discussed in MBM Report 29-1, Comprehensive Testing Program, Hydraulic Model Investigation, dated August 1971.

Model Put on Standby Basis

65. The last scheduled tests for the MBM were conducted in May 1971. With no tests scheduled, the model was put on a standby basis until further testing is requested and funds for these tests are authorized. Even though the model is on a standby basis, it is open to visitors. (Since the preparation of this report, additional tests were undertaken and scheduled for completion in September 1971.)

PART VI: PUBLIC ACCESS PROGRAM

Need for Sightseeing Facilities

66. In July 1961, it was noted that the MBM was not included in a Jackson, Miss., Chamber of Commerce folder showing points of interest to visit in and around Jackson. The MBM Board felt that the largest hydraulic model in the world would be of interest to tourists and should certainly be included in such a folder.

Facilities Provided

67. In FY 1964, construction of visitor facilities was begun to provide "self-guided" tours from 8:30 a.m. to 3:30 p.m. on a seven-day-a-week basis. These facilities include a visitor assembly building near Cairo, Ill., a 40-ft observation tower nearby, an operation observation room near Memphis, Tenn., and elevated platforms, walks, and sidewalks at selected locations on the model. The visitor assembly building contains restrooms and a lectern area with various maps, pictures, and other visual aids to provide visitors with information about the model and other work done by the WES and U. S. Army Engineers. The self-guided tour begins at the assembly building with a recorded lecture giving the history and other pertinent information about the model. The observation room is located in a portion of one of the control houses behind a glass partition where visitors can observe the model instruments in operation and hear a recorded lecture concerning the operation of the model. The elevated platforms, walkways, and sidewalks are near the model to provide visitors with a close look at various details of the model such as levees, highways, roughness elements, floodways, and other flood-control works.

68. The model is now publicized on road maps and in various tourist pamphlets and magazines. An average of 5000 people, including foreign engineers, engineers, CE officials, and sightseers in general, visit the MBM each year.

PART VII: ADMINISTRATION OF PROJECT

Planning

69. The preliminary study concerning the feasibility and practicability of a hydraulic model of this type and the investigation of suitable sites for such a model and the POW camp were made by personnel of the LMVD and WES under supervision of the President, MRC.

Land Acquisition and POW Camp

70. The purchase of lands for the model and the POW camp and the construction of the buildings for the POW compound and employees of WES were accomplished by the Mobile District under the supervision of the South Atlantic Division. As stated previously, prisoners of war were furnished by the Provost Marshal General.

Construction and Operation of Model

71. The design and construction of the model from its beginning until August 1945 were supervised by personnel of the WES under the direction of the MRC. In letter of 19 July 1945 to the Chief of Engineers, GEN Tyler, President, MRC, noted that progress on the model indicated that the heavy construction work on the model would be completed during that calendar year. He said,

> It is believed that the policies and programs for the subsequent development and operation of the model, so that it may serve the best interests of the Department in connection with reports and project studies, should be formulated with the active collaboration of other Division Engineers who are already interested in the model through their participation in financing, furnishing of surveys and data, and other assistance.

72. In the same letter, GEN Tyler continued,

> It is believed that the desired collaboration can best be attained through establishment by the Chief of Engineers of a special board for the Mississippi River Model.

He then recommended that the Chief of Engineers establish the board by appropriate orders and proposed that the board be composed of the following membership:

President of the Board - President, MRC

Secretary - Director, WES

Members - Special Assistants or Special Representatives of the

Chief of Engineers,
Division Engineer, MRD
Division Engineer, Ohio River Division (ORD)
Division Engineer, Southwestern Division (SWD)
Division Engineer, Upper Mississippi Valley Division (UMVD)*

Mississippi Basin Model Board

73. The Chief of Engineers in General Orders No. 12 of 4 August 1945 established the Mississippi Basin Model (MBM) Board consisting of membership as recommended by GEN Tyler with responsibility for determining policies and programs for subsequent development and operation of the model--one of its chief duties being to study and approve yearly construction programs and allocate funds for these programs. The President, MRC, was designated president of the board and the Director, WES, was made recorder. The board held its first meeting on 8-9 October 1945 at Vicksburg.

74. By General Order No. 16, dated 1 November 1949, the senior officer of the MBM Board was made president of the board vice the President, MRC, who continued as a member of the board. By General Order No. 6, dated 5 March 1957, the President, MRC, was again made president of the board without regard to seniority, and the Director, WES, was made a voting member.

75. Since its establishment the board has held 27 meetings--one each year except in 1948 and 1960 when two meetings were held. The dates and places of meetings of the board and a list of the members attending are shown in table 2.

Subcommittee on Uses and Benefits

76. The MBM Board at its sixth meeting on 13 March 1950 established

* The Upper Mississippi Valley Division was abolished in FY 1955 with its area of responsibility divided between the Lower Mississippi Valley Division (LMVD) and the North Central Division (NCD).

the Subcommittee on Uses and Benefits to evaluate the benefits expected to be derived from the MBM. A member from each Division and the Office, Chief of Engineers, was appointed to this committee and the Director, WES, was made ex officio chairman. The committee met on 30-31 October 1950, 12 December 1950, and 12-13 February 1951. The committee report was submitted to the MBM Board at its seventh meeting on 14 March 1951. Table 3 lists members present at each meeting.

Committee for Development of Future
Construction and Operation Programs

77. The president of the MBM Board in collaboration with the board members in December 1950 formed the Committee for the Development of Future Construction and Operation Programs for the MBM. A member from each Division and the Office, Chief of Engineers, was appointed to the committee with the Director, WES, as chairman. This committee met 12-13 February 1951 and presented its report to the MBM Board at its seventh meeting on 14 March 1951. Members attending the meeting are listed in table 3.

Mississippi Basin
Model Working Committee

78. The MBM Board at its seventh meeting on 14 March 1951 established a permanent committee called the Mississippi Basin Model Working Committee. The committee was formed to take the place of the Subcommittee on Uses and Benefits of the MBM, which had been appointed at the board's sixth meeting in March 1950, and the Committee for the Development of Future Construction and Operation Programs appointed by the president of the board in collaboration with the board members in December 1950. The working committee was directed to assume the responsibilities and duties of both of these temporary committees--continuing to evaluate the benefits derived from the model's use, plan and prepare yearly programs for construction and operation of the model, and make special investigations as directed by the board.

79. The working committee is composed of a representative from the Office, Chief of Engineers, and one from each of the five Divisions in the Mississippi Basin: the LMVD, UMVD, MRD, ORD, and SWD. The Director, WES, is the ex officio chairman of the committee. The committee has had 30

meetings and has submitted 18 annual reports to the MBM Board. The dates and places of the committee meetings and the members participating are shown in table 3.

Comprehensive Testing Program Subcommittee

80. The MBM Working Committee, feeling a need for closer liaison between the Divisions and the WES in the comprehensive testing program, established a "Comprehensive Testing Program Subcommittee" at its eighteenth meeting on 4 May 1961. The duties assigned to this committee were to work with engineers of the WES in analyzing the data obtained from the model, in making recommendations for modifications of the testing program, in proposing new testing programs, and in seeing that the data required for operation of the model are furnished by the Division and District offices. The first meeting of the subcommittee was held with the working committee on 12 July 1961, for the purposes of acquainting the subcommittee members with their duties and of furnishing them background material for carrying on their work.

81. The subcommittee held two 3- to 5-day meetings every fiscal year following its establishment, except in 1964, when only one meeting was held. The subcommittee submitted seven annual reports to the working committee and held its thirteenth and last meeting on 27-29 February 1968. The dates and places of the committee meetings and members participating are shown in table 4. Upon the completion of the comprehensive testing program, the subcommittee was dissolved.

Computer Study Group

82. In correspondence dated 17 November 1967 from the Office, Chief of Engineers, to the President, MRC, it was suggested that the MBM Board submit pertinent recommendations concerning the advisability of developing comprehensive computer programs for use after testing is terminated on the model. The working committee was of the opinion that comprehensive computer programs should be developed and that model tests could be helpful in developing these programs, especially in determining the effects of levee crevasses, operation of floodways, etc. Accordingly, the working committee prepared a Technical Studies Work Plan (TSWP) for a Mississippi River Basin

Computer Application Study and recommended its approval. The MBM Board at its twenty-fifth meeting on 4 June 1968 approved, in principle, the TSWP and instructed the working committee to establish a work group to develop a more detailed TSWP and to conduct the study.

83. The working committee organized the Computer Study Group and met with its members on 21 October 1968 to prepare guidelines for the Computer Study Group to use in developing a more detailed TSWP and in conducting the Computer Application Study. In addition to this organizational meeting, the Computer Study Group met on 23 October 1969, and developed a Computer Application Study Plan to present to the working committee.

84. Attendance of members at the Computer Study Group meetings was as follows:

Office Represented	Dates of Meetings: 21 October 1968*	23 October 1969	7 January 1971*
WES	M. B. Boyd**	M. B. Boyd**	M. B. Boyd**
OCE	A. L. Cochran†	A. L. Cochran	Verle Farrow†
LMVD	R. E. Louque	R. E. Louque	R. E. Louque
MRD	C. W. Timberman	C. W. Timberman	C. W. Timberman
ORD	J. T. Mitchell, Jr.	J. T. Mitchell, Jr.	J. T. Mitchell, Jr.
SWD	R. L. Hula	R. L. Hula	R. L. Hula
NCD	H. O. Reese	--	David Sveum
HEC	--	L. R. Beard	A. J. Frederich

* Computer Study Group met with working committee.
** Coordinator of group.
† Represented OCE on working committee and Computer Study Group.

PART VIII: COSTS

85. The financing of the model has gone through a sequence that is very unusual. The construction and maintenance costs, in the beginning, were charged to the Divisions having sections to be reproduced in the model. Later, the construction, maintenance, and verification were financed with a direct appropriation from Congress with the "MRC" paying for the construction of the lower end of the Atchafalaya Basin. All operation of the model except for the comprehensive testing program (which was a basin-wide testing program) was paid for by the Division or District requesting the tests. The cost of the model by fiscal years (FY) is given in tables 5-7. The total expenditure on the model was $17,705,000 as shown in table 5 with $13,409,000 of this amount spent for construction and general maintenance (table 6) and $4,296,000 spent for operation and standby maintenance (table 7).

Construction and General Maintenance

Costs prorated to Districts

86. From the beginning of the project through FY 1947 the cost of the construction and maintenance of the MBM was paid for by the Districts with the percentage charged to each District determined by its proportion of flood-control storage volume in existing or authorized flood-control reservoirs. The percentages of the first costs and operation costs were prorated to the participating Districts as follows:

District	Percent of Total First Cost and Operation Cost	District	Percent of Total First Cost and Operation Cost
Pittsburgh	5	Rock Island	3
Huntington	5	Albuquerque	1
Cincinnati	7	Little Rock	13
Louisville	11	Tulsa	15
Nashville	8	Vicksburg	10
Kansas City	17	Memphis	2
St. Louis	3		

Funds used for model construction were obtained from the revolving fund set up for the operation of the WES with reimbursement being made by Divisions and Districts from time to time on the aforementioned pro rata basis.

87. In May 1947, the Chief of Engineers approved the prorating of the cost of the model to flood-control projects under construction in the basin. This is the basis on which model construction and maintenance were paid for FY's 1948 through 1956. Each year after the appropriations were made by Congress for construction of flood-control projects, the Office, Chief of Engineers, prorated the cost of the current model construction program to the Divisions of the Corps of Engineers in the Mississippi Basin on the basis of the ratio of construction funds allocated for flood-control projects in the basin. The Divisions in turn prorated their pro rata shares to the Districts on a similar basis.

Model becomes Congressional project

88. Beginning with FY 1957, the construction and verification of the model were financed on a direct appropriation from Congress. It was recognized that under the system of financing being used at that time, the construction of the model would extend over a lengthy period and perhaps preclude its use in current basin-wide flood-control problems. In view of this, the model was established as a Congressional project with a special appropriation, and $400,000 was approved for the project for FY 1957.

89. Subsequent requests for funds for the completion of the construction, maintenance of the completed section, and adjustment of the model were included in the budget to Congress under General Investigations, Research and Development. Funds in the amounts of $810,000; $590,000; $682,500; $700,000; $700,000; $650,000; and $461,000 were approved and provided for continuation and completion of construction and verification during FY's 1958, 1959, 1960, 1961, 1962, 1963, and 1964, respectively.

90. In FY's 1965-1971 funds were included in the budget request to Congress to maintain the model and construct and maintain public access facilities that would provide for self-guided tours of the model. Funds in the amounts of $150,000; $210,000; $170,000; $160,000; $150,000; $60,000; and $65,000 were authorized in FY's 1965, 1966, 1967, 1968, 1969, 1970,

and 1971, respectively. The budget request to Congress for FY 1972 includes $65,000 for maintenance of the model.

MRC funds construction

91. The lower limit of the Congressional project was the end of the levees on the Atchafalaya River, but the MRC had need for a model of the entire Atchafalaya Basin; therefore, it financed the construction of the remainder of the Atchafalaya Basin.

Model Operation

Prior to FY 1952

92. The cost of model operation for the first two years (FY's 1951 and 1952) was divided equally among the three Divisions having operable sections of the model--the MRD, the UMVD, and the SWD. This cost was for the verification of completed portions of the model.

FY's 1952-1958

93. Beginning in FY 1952, the cost of model operation was charged to the Division requiring the tests; however, if a Division did not require full-time operation of its completed portion of the model, it was charged with standby maintenance* for the portion not in operation. The standby maintenance funds provided for keeping the joints sealed, the instruments in good repair, and the model clean. The cost of model operation of any one of the completed sections of the model was as follows:

Percent of Operation	Cost per Division per Year
100	$133,000
50	85,000
Standby maintenance (no operation)	15,800

If a Division had partial model operation, a proportionate share of these costs was charged.

* Standby maintenance was discontinued after the model became a Congressional project.

FY's 1959-1972

94. In FY 1959, the comprehensive testing program (a basin-wide testing program) was begun with funds provided by Congress. This testing program continued through FY 1969 with annual appropriations from Congress. In FY 1970 Congressional funds of $40,000 were appropriated to complete the report of the testing program and to prepare this report. In FY 1971, Congress appropriated $150,000 to conduct a Computer Application Study. These funds were approved so late in 1970 that the study could not be completed in FY 1971; thus, it was necessary to carry part of this $150,000 over into FY 1972 to complete the study.

95. During this period, all tests of local flood-control problems continued to be sponsored and paid for by the Division or District requesting the tests.

PART IX: CONCLUSIONS

96. The MBM has been a very effective tool for the engineer in his efforts to control flooding in the Mississippi River Basin. Model data, having been used to aid in determining design heights of comprehensive levee systems, to evaluate effects of various levee alignments, to check reservoir operation procedures, to aid in flood prediction in the 1952 flood on the Missouri River, etc., have been useful in saving millions of dollars in cost of constructing levees and other flood protection works, in preventing or reducing flood damages, and in the establishment of parameters to be used in developing more reliable computer programs. Since the comprehensive testing program for which the model was designed has been completed and present-day computers have been refined and their memory units enlarged to the extent they can do much flood-routing that was previously reserved for models, the need for the model has been limited to special tests of local problems and demonstrations for local interests.

97. The MBM was placed on standby and will be maintained in this status until it is definitely established that there is no further need for the model. The model and facilities will then be declared surplus and disposed of in accordance with existing regulations.

Table 1

Tests Conducted on the MBM

Sponsor	No.	Ident No.	Title	Date
OCE	1	--	OCE Abrupt Wave Study (Classified Project)	Feb 1951
	2	29-1	Comprehensive Testing Program	Aug 1971
LMVD	1	15-1	Verification of Hannibal-to-St. Louis Reach, Mississippi River and Tributaries, 1947, 1944, and 1943 Floods	Aug 1951
	2	15-2	Verification of Hannibal-to-Thebes Reach, Mississippi River and Tributaries, 1947, 1944, and 1943 Floods	May 1952
	3	--	Verification of Mississippi River and Tributaries from Thebes and Golconda to Baton Rouge on Mississippi River and Gulf on Atchafalaya	1970
	4	31-1	Operation of Birds Point-New Madrid Floodway	July 1957
	5	31-2	Adequacy of Project Levee Grades in Hannibal-to-Thebes Reach, Mississippi River and Tributaries	Apr 1957
	6	--	Effects of Upstream Reservoirs on the Project Flood--Vicinity of Confluence, Ohio and Mississippi Rivers	Apr 1957
	7	81-1	Effects of Proposed Highway Fill Across Chouteau Island	Jan 1959
	8	81-2	Effects of Proposed Chain of Rocks Dam, Mississippi River, Mile 190.1	Sept 1959
	9	31-3	Proposed Alignments for Columbia Bottoms Levee, St. Louis Industrial Park	Jan 1960
	10	31-4	Mississippi River Hypothetical Flood 52A	Sept 1962
	11	86-1	Effects of Roadway Embankment and Waterway Openings of Proposed Interstate Highway 155 on Mississippi River Floods	July 1966
	12	--	Model Study, Mississippi River at Jefferson Barracks Bridge	Oct 1966

(Continued) (1 of 6 sheets)

Table 1 (Continued)

Sponsor	No.	Ident No.	Title	Date
LMVD (Contd)	13	--	Demonstration of Flood Protection Works for Members of Delta Council	Feb 1967
	14	--	Demonstration of Flood Protection Works for Members of Various Levee Boards in Lower Mississippi River Area	July 1967
	15	--	Tests of the Proposed Industrial Development, Presidents Island	Nov 1967
	16	81-3	Effects of Roadway Construction on Mississippi River Flow, Lake County, Tennessee	Dec 1967
	17	--	Demonstration of Flow Conditions Expected at I-155 Highway Crossing near Caruthersville	May 1969
	18	--	Effects of I-155 and Lake County Roadways	Sept 1969
	19	--	Effects of I-155 and Lake County Roadways on Mississippi River and Obion River Flows	Sept 1969
	20	--	Tests of Channel Realignment near Baton Rouge, Louisiana	Oct 1969
	21	--	Demonstration of Effects of Operating Old River Control Structure to Control Stages at Acme, Louisiana	Dec 1969
	22	--	Demonstration of Flood Protection Works for Members of Fish and Wildlife Agencies in Atchafalaya River Basin	Feb 1970
	23	--	Effects of Tiptonville-Obion Levee on Project Design Flood and Steady Flow Tests, Cairo-to-Arkansas City Reach	July 1970
	24	--	Tests of Proposed Loop Levees in the Vicksburg District	Sept 1970
	25	--	Tests of Mississippi River Routing and Storage Characteristics	Oct 1970
	26	--	Model Study of Effects of Fully Protecting Backwater Areas in Memphis and Vicksburg Districts	Nov 1970

(Continued)

Table 1 (Continued)

Sponsor	No.	Ident No.	Title	Date
LMVD (Contd)	27	--	Tests in the Lower Atchafalaya River Basin	Oct 1971
	28	31-5	Effects of Height and Alignment of Levees Near Confluence of Missouri and Mississippi Rivers	1971
	29	--	Effects of Proposed Levees in Miller City Area and Steady Flow Tests in St. Louis-to-Wickliffe Reach	1971
	30	--	Tests to Determine the Effects of Enlarging Atchafalaya River and to Determine Inundated Areas for Various Flows	1971
	31	--	Effects of Operating Old River Control Structure to Control Stages at Acme, La.	1971
MRD	1	12-1	Verification of Sioux City-to-Hermann Reach, Missouri River and Tributaries, 1950 and 1947 Floods	Apr 1952
	2	12-2	Verification of Sioux City-to-Mouth Reach, Missouri River and Tributaries, 1952 and 1951 Floods	June 1962
	3	--	Fort Randall Shutoff Tests	Oct 1951
	4	--	Emergency Flood Tests During the 1952 Flood	Apr-May 1952
	5	--	Determination of Flood Stages	Oct 1952
	6	--	Demonstration for Iowa Power and Light Co.	Oct 1952
	7	--	Demonstration for CB & Q RR Personnel	1953
	8	--	Demonstration for Members of Missouri River Division and Mississippi Valley Improvement Association	1954
	9	52-1	Tests of Channel Realignment near St. Joseph, Missouri	Oct 1954

(Continued)

Table 1 (Continued)

Sponsor	No.	Ident No.	Title	Date
MRD (Contd)	10	32-1	Effects of Agricultural Levees on Design Flood Profiles for Kansas City Local Protection	May 1955
	11	92-1	Effects of Flood Heights of Levee, Railroad, and Highway Fills in the Floodplain of the Missouri River	Oct 1955
	12	--	Routing Characteristics of Missouri River Troughs	Dec 1955
	13	42-1	Hypothetical Storms over the Iowa Tributaries	Oct 1956
	14	--	Demonstration for Committee of Association of American Railroads and American Railway Engineering Association	1957
	15	--	Demonstration for Missouri River Basin and Arkansas-White-Red River Basins Inter-Agency Commission	1957
	16	32-2	Tests for Re-evaluation of Missouri River Agricultural Levees in the Kansas City District	Dec 1959
	17	32-3	Tests for Re-evaluation of Missouri River Agricultural Levees in the Omaha District	May 1960
	18	--	Tests to Determine Model Characteristics	Nov 1969
ORD	1	--	Verification of Cumberland River	Aug 1955
	2	13-1	Verification of the Pickwick Dam-Kentucky Dam Reach, Tennessee River and Tributaries, 1950 and 1948 Floods	Dec 1960
	3	--	Verification of Louisville-to-Golconda Reach, Ohio River and Tributaries	Mar 1970
	4	43-1	The Ohio River Hypothetical Flood OR-1	Feb 1962
	5	23-1	Effects of Reservoirs and Results of Steady-Flow Tests, Cumberland River	June 1965

(Continued)

Table 1 (Continued)

Sponsor	No.	Ident No.	Title	Date
ORD (Contd)	6	23-2	Kentucky Reservoir Steady Flow Profiles and Effects of Pickwick Discharge Duration on Downstream Stages	July 1965
	7	--	Tests for Lower Ohio River	Apr 1966
	8	23-3	Effects of Cheatham and Barkley Reservoirs and Coordinated Operation of Barkley and Kentucky Reservoirs, Cumberland and Tennessee Rivers	May 1969
	9	33-1	Comprehensive Levee System--Wabash River, Riverton, Indiana, to the Mouth	1971
	10	--	Effects of Proposed Gibson Power Plant on Wabash River Flood Flows	Apr 1971
SWD	1	14-1	Verification of Tulsa-to-Van Buren Reach, Arkansas River and Tributaries, Spring 1941 and 1943 Floods	July 1951
	2	14-2	Verification of Van Buren-to-Pine Bluff Reach, Arkansas River and Tributaries, Spring 1941 and 1943 Floods	Nov 1952
	3	--	Tests to Determine Effects of Tulsa-West Tulsa and Jenks Levee	June 1953
	4	--	Tests to Determine Effects of Rate of Rise on Stage-Discharge Relationship	Mar 1954 and June 1956
	5	44-1	Determination of Discharge Hydrographs for Arkansas River and Tributaries, April 1927 Flood	June 1956
	6	34-1	Effects of Project Levees Along Point Remove Creek, Tributary of Arkansas River	June 1956
	7	--	Tests to Determine Backwater Effects on Arkansas River and Tributaries	Sept 1956
	8	--	Development of Unit Hydrographs for Model Inflow Points on Ungaged Tributaries of Arkansas River	Oct 1956

(Continued)

Table 1 (Concluded)

Sponsor	No.	Ident No.	Title	Date
SWD (Contd)	9	34-2	Adequacy of Project Levee Grades Without and With Reservoir Modification, Van Buren to Pine Bluff, Arkansas River	Apr 1957
	10	MP 2-331	Ungaged Flows for 1949, 1950, and 1951 Floods--Van Buren to Little Rock Reach	Mar 1959
	11	24-1	Flood-Routing and Reservoir-Operation Study, Tulsa-to-Van Buren Reach, Arkansas River and Tributaries	Apr 1961
	12	--	Tests to Assist in Developing Computer Programs	Sept 1969

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[illegible] 1967	Jackson, Miss.	Mr. [illegible] Williams, Jr.	MGD
		Mr. [illegible]	[illegible]
		Mr. [illegible]	[illegible]
		Mr. [illegible]	[illegible]
		Mr. [illegible]	[illegible]
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[illegible]	[illegible]	Mr. [illegible]	[illegible]
		Mr. [illegible]	[illegible]

Table 4

Attendance at MBM Comprehensive Testing

Program Subcommittee Meetings

Meeting No.	Date	Members Attending	Installation Represented
1	16-20 Oct 1961	F. B. Toffaleti	LMVD
		M. A. Clare	MRD
		E. A. Lawler	ORD
		L. E. Hough	SWD
		H. C. McGee	WES
2	24-26 Apr 1962	F. B. Toffaleti	LMVD
		M. A. Clare	MRD
		E. A. Lawler	ORD
		L. E. Hough	SWD
		H. C. McGee	WES
3	28-29 Nov 1962	F. B. Toffaleti	LMVD
		M. A. Clare	MRD
		E. A. Lawler	ORD
		L. E. Hough	SWD
		H. C. McGee	WES
4	21-23 May 1963	C. L. Sumrall*	LMVD
		M. A. Clare	MRD
		E. A. Lawler	ORD
		L. E. Hough	SWD
		H. C. McGee	WES
5	4-6 Feb 1964	F. B. Toffaleti	LMVD
		M. A. Clare	MRD
		E. A. Lawler	ORD
		L. E. Hough	SWD
		H. C. McGee	WES
6	6-8 Oct 1964	F. B. Toffaleti	LMVD
		M. A. Clare	MRD
		E. A. Lawler	ORD
		L. E. Hough	SWD
		J. N. Stephenson	NCD
		H. C. McGee	WES
7	9-11 Feb 1965	F. B. Toffaleti	LMVD
		M. A. Clare	MRD
		J. T. Mitchell, Jr.	ORD
		L. E. Hough	SWD
		W. T. Collins	OCE
		J. N. Stephenson	NCD
		H. C. McGee	WES

(Continued)

* Represented LMVD for F. B. Toffaleti.

Table 4 (Concluded)

Meeting No.	Date	Members Attending	Installation Represented
8	2-4 Nov 1965	F. B. Toffaleti	LMVD
		M. A. Clare	MRD
		J. T. Mitchell, Jr.	ORD
		H. J. Schwartz	SWD
		D. E. Nunn	OCE
		J. N. Stephenson	NCD
		H. C. McGee	WES
9	1-3 Feb 1966	F. B. Toffaleti	LMVD
		M. A. Clare	MRD
		J. T. Mitchell, Jr.	ORD
		H. J. Schwartz	SWD
		D. E. Nunn	OCE
		J. N. Stephenson	NCD
		H. C. McGee	WES
10	15-17 Nov 1966	F. B. Toffaleti	LMVD
		M. A. Clare	MRD
		J. T. Mitchell, Jr.	ORD
		H. J. Schwartz	SWD
		D. E. Nunn	OCE
		H. C. McGee	WES
11	28 Feb-2 Mar 1967	F. B. Toffaleti**	LMVD
		M. A. Clare	MRD
		J. T. Mitchell, Jr.	ORD
		H. J. Schwartz	SWD
		D. E. Nunn	OCE
		J. E. Foster	WES
12†	1-2 Nov 1967	F. B. Toffaleti	LMVD
		M. A. Clare	MRD
		J. T. Mitchell, Jr.	ORD
		H. J. Schwartz	SWD
		D. E. Nunn	OCE
		R. E. Emmenegger	NCD
		J. E. Foster	WES
13	27-29 Feb 1968	F. B. Toffaleti	LMVD
		M. A. Clare	MRD
		J. T. Mitchell, Jr.	ORD
		H. J. Schwartz	SWD
		D. E. Nunn	OCE
		J. E. Foster	WES

** Attended only 28 Feb; E. J. Williams, Jr., represented LMVD on 1-2 Mar.
† This meeting was held in Vicksburg, Miss.; all other meetings were held in Jackson, Miss.

Table 5

Total Model Cost by Fiscal Years

FY	Construction*	General Maintenance	Operation and Standby Maintenance	Total
1944	$ 261,556	--	--	$ 261,556
1945	339,088	--	--	339,088
1946	539,344	$ 65,267	--	604,611
1947	524,974	9,712	--	534,686
1948	1,136,021	26,740	$ 3,239	1,166,000
1949	1,067,292	9,037	78,563	1,154,892
1950	1,175,977	66,173	203,593	1,445,743
1951	222,357	43,668	282,948	548,973
1952	78,848	17,560	302,926	399,334
1953	149,433	40,687	232,267	422,387
1954	310,624	44,625	184,052	539,301
1955	404,649	63,161	186,940	654,750
1956	433,496	60,316	151,263	645,075
1957	434,519	31,310	189,819	655,648
1958	678,662	74,218	22,808	775,688
1959	569,526	102,314	111,234	783,074
1960	562,021	104,430	117,247	783,698
1961	572,386	112,675	174,363	859,424
1962	524,781	102,921	159,847	787,549
1963	424,434	96,128	211,678	732,240
1964	321,751	114,984	252,210	688,945
1965	152,116	114,693	212,624	479,433
1966	81,297	181,211	223,094	485,602
1967	272,721	167,746	237,702	678,169
1968	8,582	173,709	246,751	429,042
1969	1,675	156,234	191,066	348,975
1970	951	64,171	143,307	208,429
1971	3,746	67,197	176,362**	247,305**
1972	--	65,000†	--	65,000†
Total	$11,252,827	$2,175,887	$4,295,903	$17,724,617

* Includes planning, design, and instrumentation costs.

** Includes $150,000 for Computer Application Study. Some of these funds will be carried over into FY 1972.

† The budget request to Congress for FY 1972 includes $65,000 for general maintenance of the model.

Table 6

Annual Construction* and General Maintenance Costs

by Division and Congressional Funds

FY	Division Funds: LMVD	MRD	UMVD** and NCD	ORD	SWD	Congressional Funds	Total
1944	$ 31,387	$ 44,464	$ 15,694	$ 94,160	$ 75,851	--	$ 261,556
1945	40,691	57,645	20,345	122,072	98,335	--	339,088
1946	72,553	102,784	36,277	217,660	175,337	--	604,611
1947	64,162	90,897	32,081	192,487	155,059	--	534,686
1948	267,435	325,573	58,138	267,435	244,180	--	1,162,761
1949	226,029	301,372	43,054	269,082	236,792	--	1,076,329
1950	335,380	322,959	37,265	260,851	285,695	--	1,242,150
1951	58,526	93,109	5,320	50,545	58,525	--	266,025
1952	25,066	35,671	5,785	13,497	16,389	--	96,408
1953	57,036	79,850	7,605	30,419	15,210	--	190,120
1954	117,232	152,757	14,210	46,182	24,868	--	355,249
1955	126,309	210,514	18,712	84,206	28,069	--	467,810
1956	145,099	151,379	23,216	104,471	69,647	--	493,812
1957	--	80,579	--	--	--	$ 385,250	465,829
1958	--	6,453	--	--	--	746,427	752,880
1959	--	--	--	--	--	671,840	671,840
1960	4,954	--	--	--	--	661,497	666,451
1961	--	--	--	--	--	685,061	685,061
1962	--	--	--	--	--	627,702	627,702
1963	49,689	--	--	--	--	470,873	520,562
1964	136,539	--	--	--	--	300,196	436,735
1965	728	--	--	--	--	266,081	266,809
1966	12,166	--	--	--	--	250,342	262,508
1967	23,502	--	--	--	--	416,965	440,467
1968	--	--	--	--	--	182,291	182,291
1969	--	--	--	--	--	157,909	157,909
1970	--	--	--	--	--	65,100	65,100
1971	--	--	--	--	--	70,943	70,943
1972	--	--	--	--	--	65,000	65,000
Total	$1,794,483	$2,056,006	$317,702	$1,753,067	$1,483,957	$6,023,499	$13,408,714

* [illegible] planning, design, and instrumentation costs.

** [illegible] was abolished in FY 1955 with its area of responsibility divided between [illegible] and the [illegible].

Table 7

Annual Operation and Standby Maintenance Costs

by Division and Congressional Funds

FY	Division Funds					Congressional Funds	Total
	LMVD	MRD	UMVD* and NCD	ORD	SWD		
1948	--	$ 3,239	--	--	--	--	$ 3,239
1949	--	28,528	$ 30,411	--	$ 19,624	--	78,563
1950	--	75,747	64,183	--	63,663	--	203,593
1951	--	108,335	83,415	--	91,198	--	282,948
1952	--	157,173	73,209	--	72,544	--	302,926
1953	--	122,515	16,584	$ 14,434	78,734	--	232,267
1954	$ 2,037	89,758	19,039	16,926	56,292	--	184,052
1955	17,792	98,458	--	44,657	26,033	--	186,940
1956	39,180	65,383	--	29,809	16,891	--	151,263
1957	46,106	95,837	--	30,925	16,951	--	189,819
1958	971	19,849	--	1,454	534	--	22,808
1959	7,447	22,178	--	8,549	229	$ 72,831	111,234
1960	941	2,678	--	13,446	--	100,182	117,247
1961	1,756	5,935	--	16,252	--	150,420	174,363
1962	--	437	--	653	--	158,757	159,847
1963	--	585	--	10,661	--	200,432	211,678
1964	--	21,174	--	18,283	--	212,753	[illegible]
1965	--	538	--	7,507	--	204,579	[illegible]
1966	8,049	2,409	--	5,781	--	206,855	223,094
1967	7,236	4,790	--	110	--	225,566	[illegible]
1968	26,902	1,049	--	383	--	218,417	246,751
1969	24,496	9,643	--	1,366	--	155,561	[illegible]
1970	95,756	--	--	--	--	47,551	[illegible]
1971	1,257	--	--	[illegible]	--	163,471**	[illegible]**
1972	--	--	--	--	--	--	--
Total	$279,926	$936,238	$286,841	$232,870	$442,693	$2,117,379	[illegible]

* The UMVD was abolished in FY 1955 with its area of responsibility divided between the LMVD and the NCD.

** Includes $150,000 for Computer Application Study. Some of these funds will be carried over into FY 1972.

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Security Classification

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James E. Foster

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d.	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	**12. SPONSORING MILITARY ACTIVITY** Office, Chief of Engineers, U. S. Army Washington, D. C.

13. ABSTRACT

The Mississippi Basin Model reproduces the entire drainage basin of the Mississippi River and its tributaries to a horizontal scale of 1:2000 and a vertical scale of 1:100. Construction of the model was begun in 1943 and was completed in 1966. Testing of local problems for various Corps of Engineers Division and District offices within the basin was begun in 1949. Tests were conducted as requested by Division and District offices until 1971 when all scheduled tests were completed. A comprehensive testing program begun in 1959 was completed in 1969. Tests to aid in the development of computer programs were conducted from 1969 to 1971. The model is now on standby maintenance pending need for additional tests and is operated for viewing by technical visitors and the general public. The comprehensive tests have been very effective in checking the adequacy of operational procedures for flood-control reservoirs and floodways in the basin. The special tests have been invaluable in assisting the Divisions and Districts in determining the design grade of levees and floodwalls, in demonstrating to levee board members and other interested persons the effectiveness of flood-control structures constructed or proposed by the U. S. Army Engineers, etc. The most spectacular use of the model was in flood prediction on the Missouri River during the April 1952 flood when the model was instrumental in pinpointing critical points along levees. The model tests indicated some levees should be raised and others would be overtopped to such an extent that there would not be time enough to raise them. The Mississippi Basin Model Board (the group charged with determining policies and programs for development and operation of the model) unanimously agreed that the model has been a very valuable tool in solving many flood-control problems and in coordinating the operation of reservoirs within the basin.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Hydraulic models						
Mississippi Basin Model						

Unclassified
Security Classification

Key to Numbering of MRM Reports*

Type of Report or Test	Office for which Conducted									
	General	LMVD	MRD	ORD	SWD	UMVD	Reserved for Future	Reserved for Future	Inter-Division	Basin-wide
General Reports	1-series									
MBM Board Meetings	2-series									
Papers in Technical Journals	3-series									
Reserved for Future	4-series									
Reserved for Future	5-series									
Reserved for Future	6-series									
Reserved for Future	7-series									
Reserved for Future	8-series									
Reserved for Future	9-series									
Verification Studies	10-series	11-	12-	13-	14-	15-	16-	17-	18-	19-
Reservoir-Operation Studies	20-series	21-	22-	23-	24-	25-	26-	27-	28-	29-
Levee Studies	30-series	31-	32-	33-	34-	35-	36-	37-	38-	39-
Flood-Routing Studies	40-series	41-	42-	43-	44-	45-	46-	47-	48-	49-
Changes in Regimen	50-series	51-	52-	53-	54-	55-	56-	57-	58-	59-
Reserved for Future	60-series									
Reserved for Future	70-series									
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Combined-Purpose Studies	90-series	91-	92-	93-	94-	95-	96-	97-	98-	99-

* **First digit indicates** type of report or test; second digit (for 10-series and above) indicates office **for which performed. Numbers** following dashes indicate chronological order in respective series.

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